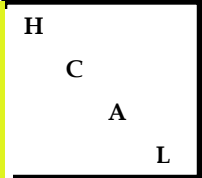




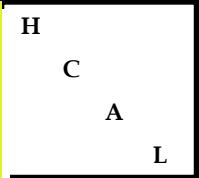
# HPD HV System



**CMS HCAL ESR**  
**December 3-6, 2002**  
**S. Los**  
**Fermilab**



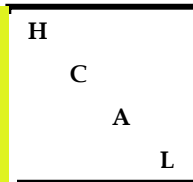
# Outline



- HPD power requirements
- HV system architecture
- HV power supply
- HV rack
- HV cable
- HV distribution in RBX
- HV safety box
- Tests
- Summary



# HPD Power Requirements



## HPD versus PMT:

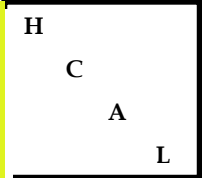
Needs very low common / differential noise

Tolerant to DC voltage stability

- High voltage 12 kV
- HV current 400pA
- Bias voltage 200 V
- BV current 2  $\mu$ A
- Noise floor  $< 3 \text{ pA}/(\text{Hz})^{1/2}$



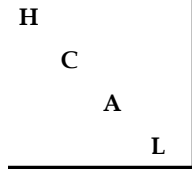
# HV System Outline



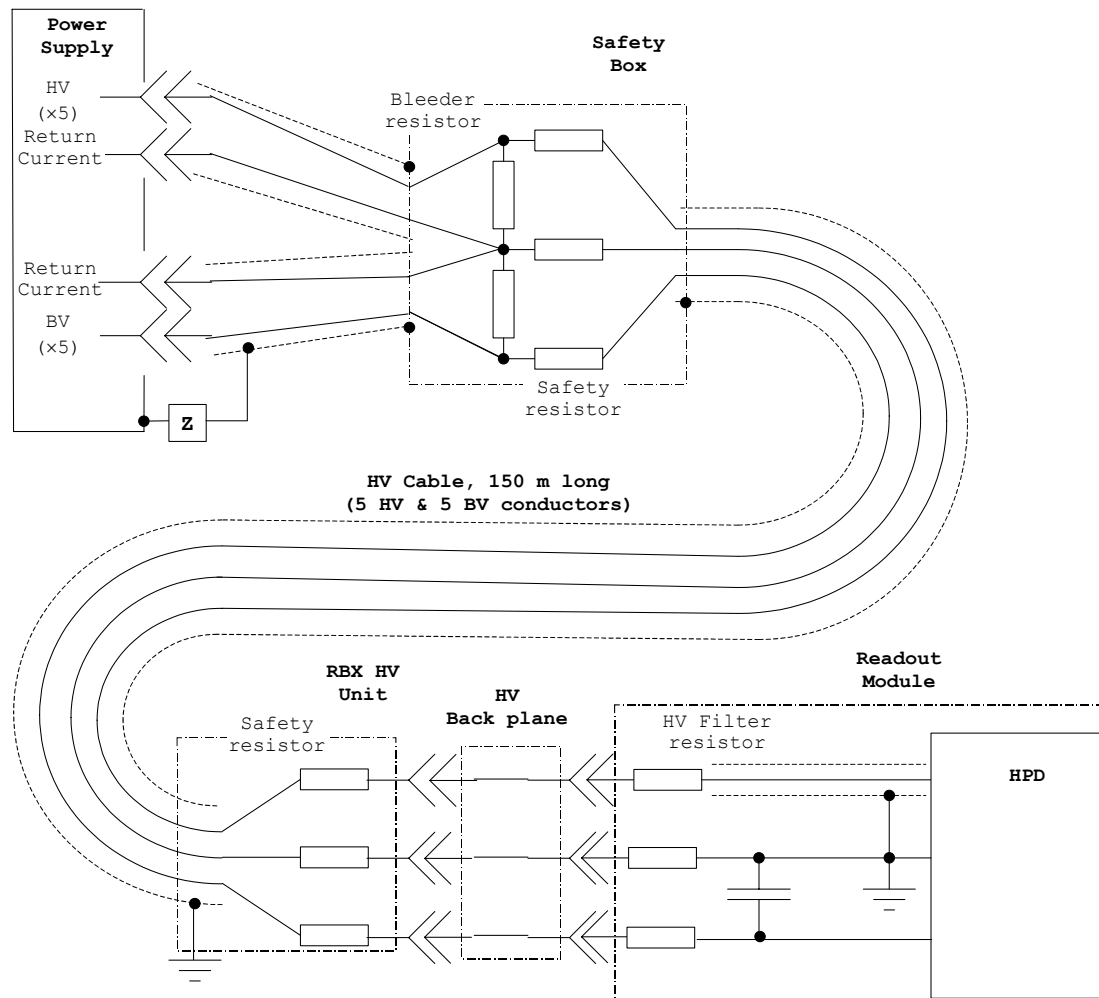
- Individually regulated HV and BV for each HPD
- HV power supplies are in the counting room
  - No radiation (Si high voltage components)
  - Easily repairable
- Cable distribution network (1 RBX - 1 Cable)
  - Cable near / far end filters
  - Incorporates safety elements (bleeder resistors and discharge current limiters)
- Differential/Common mode filter is on the HPD
  - Decreases pickup noise



# HV System Architecture

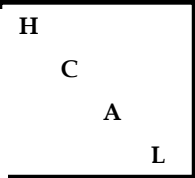


## HPD power distribution diagram





# HV Power Supply

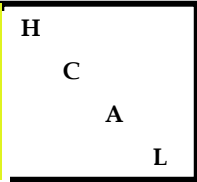


## Modular PS designed in INRNE, Bulgarian Academy of Sciences

	High Voltage	Bias Voltage
Output	Floating, to allow single point grounding at the detector	
Max. output voltage	12 kV	200 V
Max. output current	40uA	10uA
Voltage resolution	3V	50 mV
Current resolution	10nA	2.5nA
Voltage ripple	100 mV	1 mV
Ramping	0÷1000 V/s	0÷100 V/s
Long term voltage stability	<0.1%	
Voltage/current monitor accuracy	1%/1%	
Protection	Overvoltage hardware protection, slow trip on overvoltage and overcurrent	
Parameters under control	Output voltage, ramp rate, thresholds for slow overvoltage and overcurrent trips	
Monitored parameters	Output voltage, output current, hardware voltage limit, software limits for the trips	

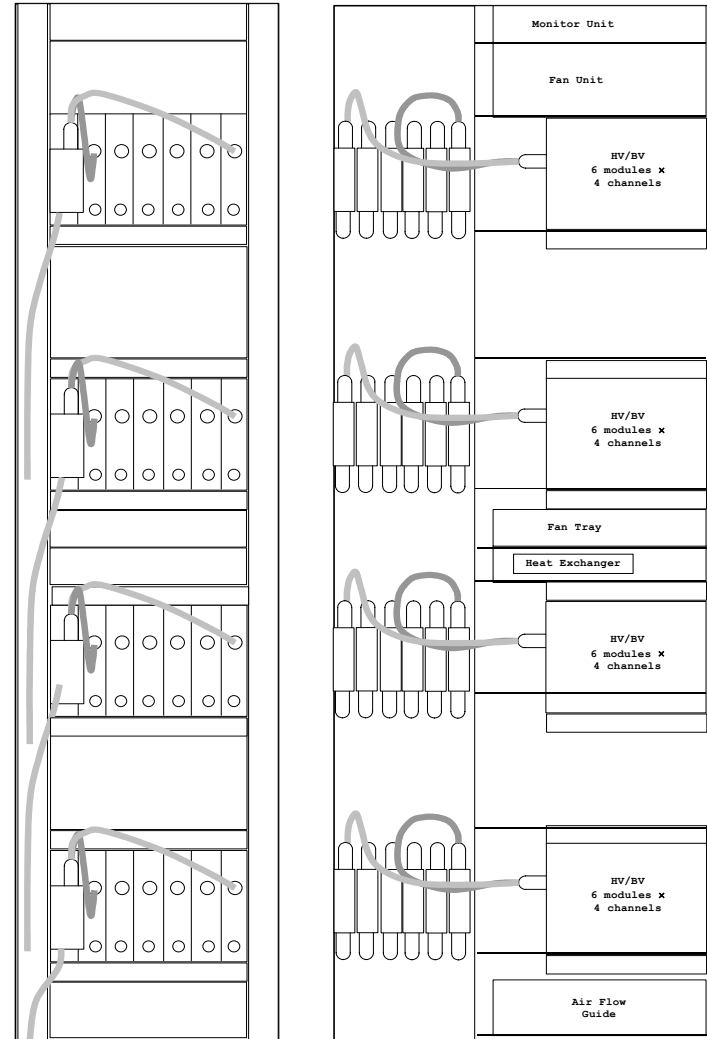


# HPD HV Rack



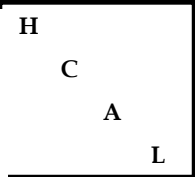
## Organization

- 5 racks in control room
- 4 HV 6U crates per rack
- 6 HV modules per crate
- 1 HV module supplies up to 4 HPDs in a RBX
- HV cable connects to the rear end connector
- There is a slow control system console in one of the racks





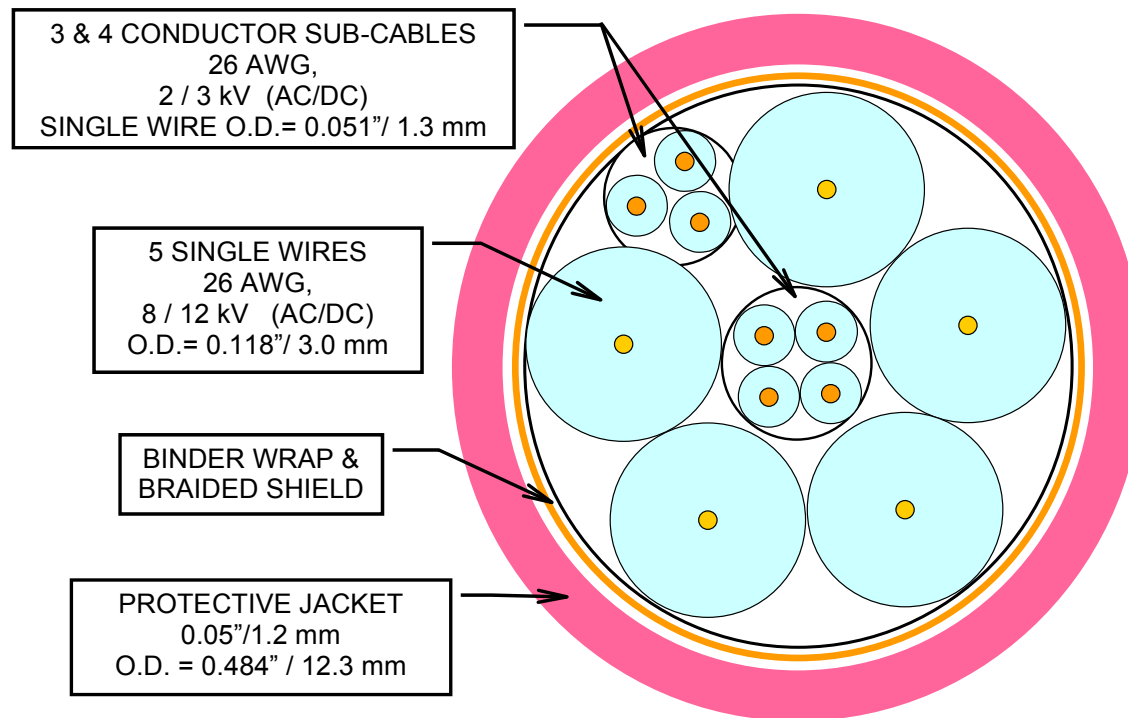
# HV Cable



**Kerpen Special, part # PE 296 901**

**Composition: 5×12 kV, 7 ×200 V wires, shield.**

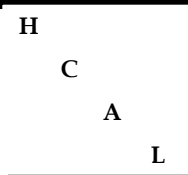
**Complies with CERN IS-23/IEC 60332-3**



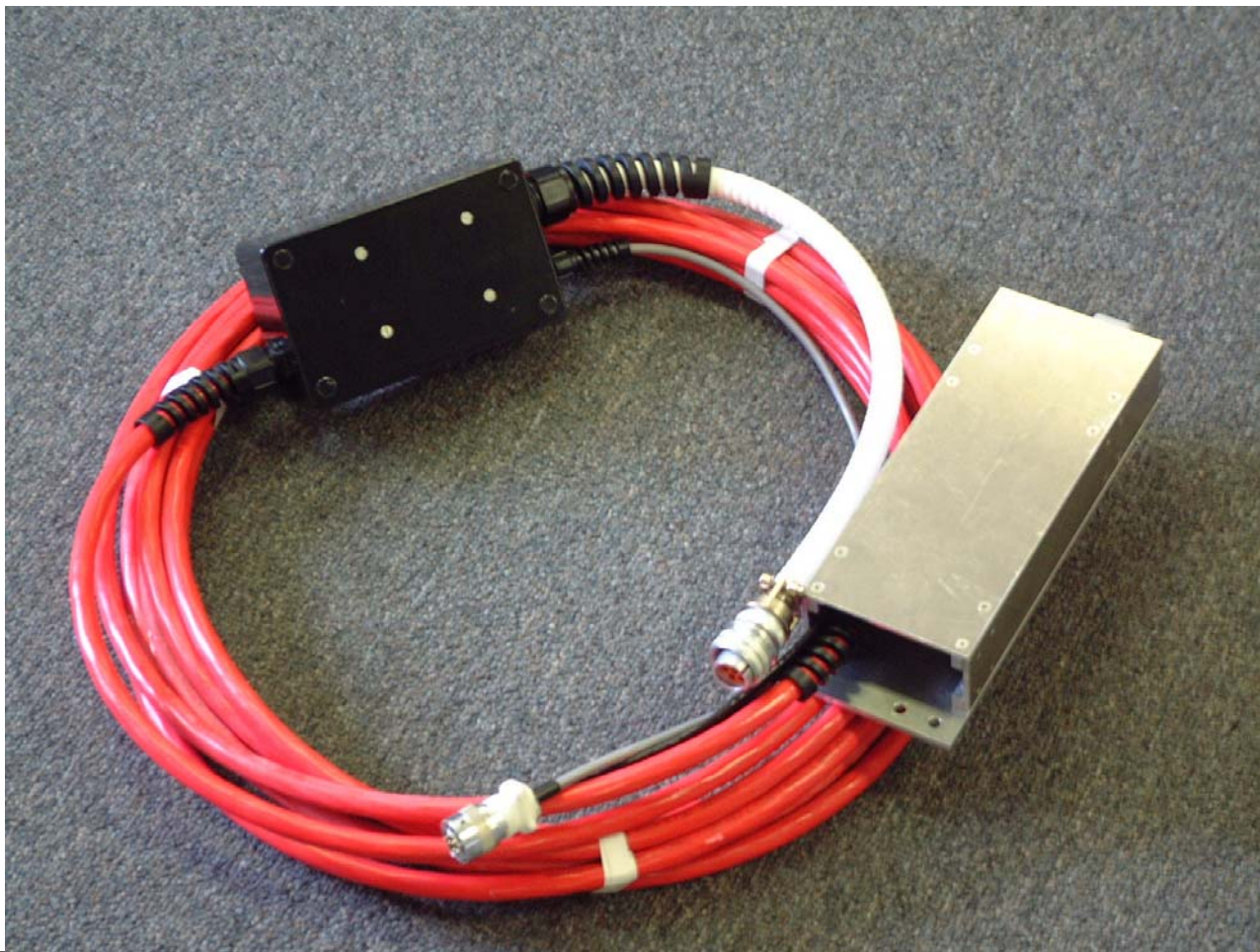




# HV Cable

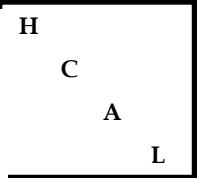


## 2002 Test Beam HV Cable

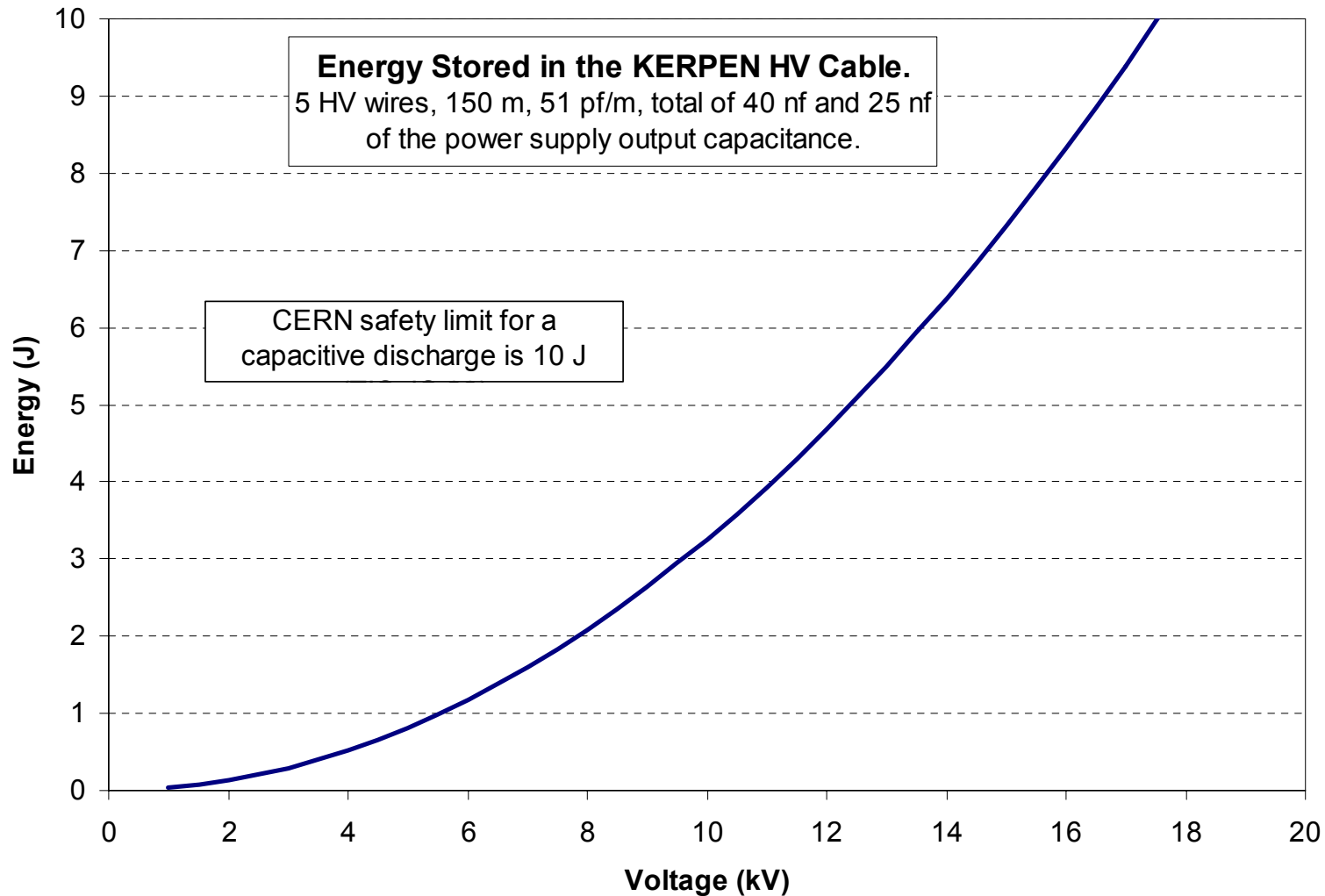




# Stored Energy

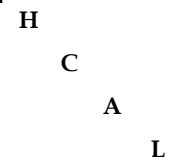


At 12 kV stored energy is below CERN safety limit

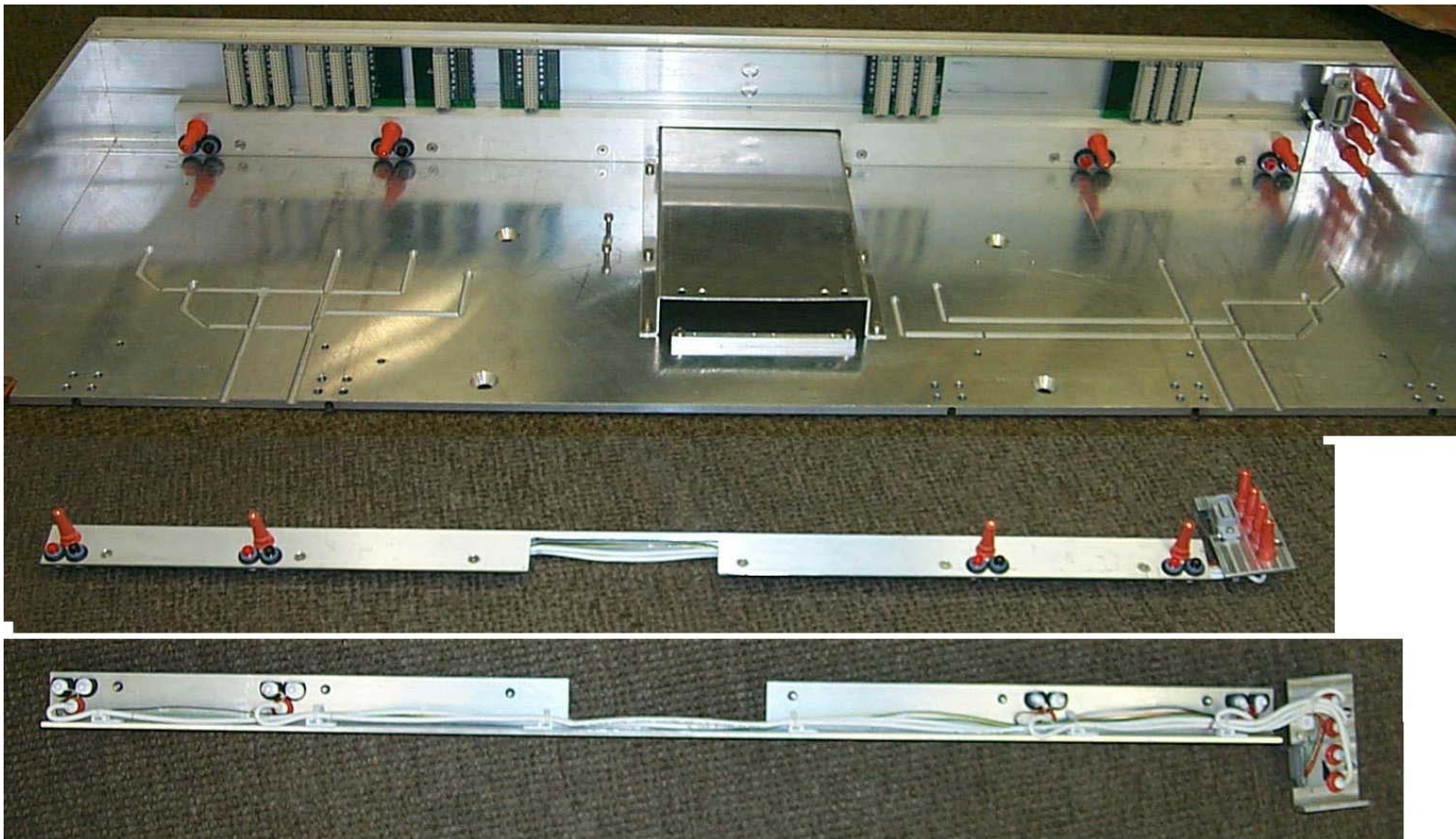




# HV Distributor



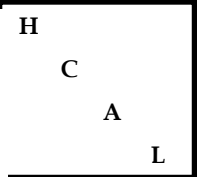
## HV/BV distribution within RBX







# HV Unit



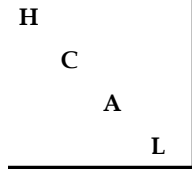
**HV Unit connects a HV cable to a HV distributor**  
**High voltage components are potted on one side of the PCB**

**Units are assembled in the lab, and can be attached to the cables at the spot**





# HV Safety Box

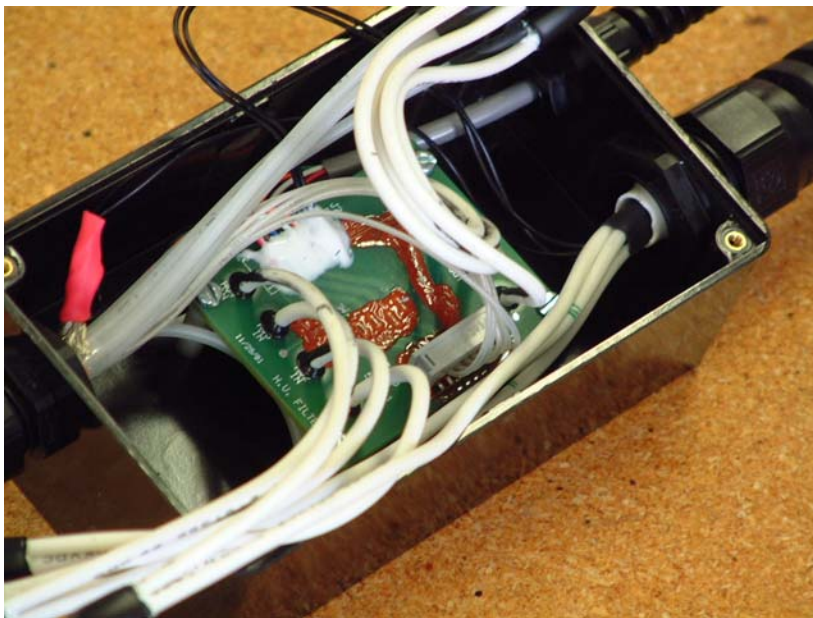


Uses the same HV PCB as the HV Unit (with different components installed)

Connects HV cable to the HV and BV power supplies

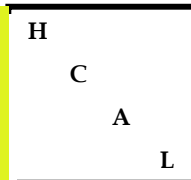
Provides ground separation (100 Kohm), cable discharge (bleeder resistors), and preliminary voltage filtering

Most of the problems came from the HV connector pigtail – finally we decided to fix that connector directly on the Safety Box

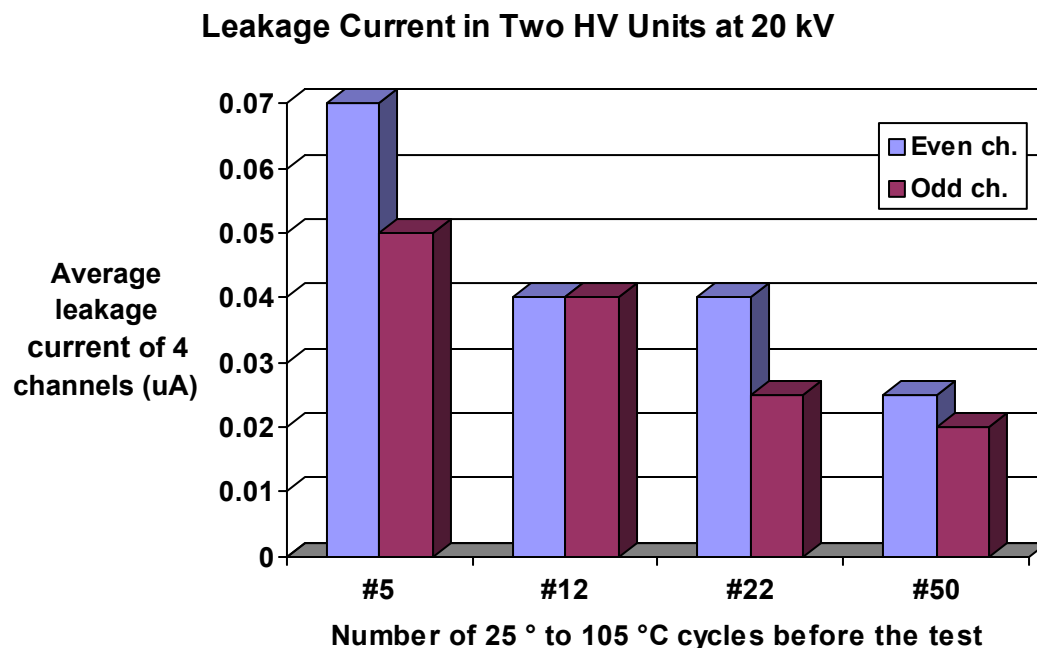




# Tests-1

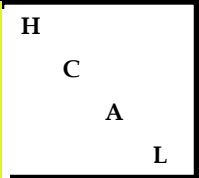


- 2 HV Units were thermo cycled as they include all the components used in the HV distribution
  - +25 to +105°C
  - 50 cycles





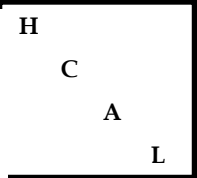
# Tests-2



- Accelerated aging test is under its way
  - 2 HV Units
  - HV Cable at 25 mm bending radius
- **“Simplified Protocol”**  $\times 2/10^{\circ}\text{C}$ 
  - Accumulation is 317 days so far
  - No visual or detectable leakage current changes in the Cable at 18 kV DC
  - HV Units were not tested yet as they are of a much smaller concern



# Summary



- All components of the HV System were successfully prototyped and tested both in the Lab and at the Test Beam
- Internal technical issues has been resolved
- Safety issues are O.K.
- Our main concern is about the small bending radius along the cable tray